

Bibliography

- [1] Milton Abramowitz and Irene A. Stegun. *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*. Dover, 1970.
- [2] Alexander Aitken. On Bernoulli's numerical solution of algebraic equations. *Proceedings of the Royal Society of Edinburgh*, 46:289–305, 1926.
- [3] Robert S. Anderssen and Gene H. Golub. Richardson's non-stationary matrix iterative procedure. Technical Report CS-TR-72-304, Computer Science Department, Stanford University, 1972.
- [4] Bengt Aspvall and John R. Gilbert. Graph coloring using eigenvalue decomposition. *SIAM J. Alg. Disc. Meth.*, 5(4), 1984.
- [5] Forbes A. B. Geometric tolerance assessment. *TR DITC 210/92, National Physical Laboratory, Teddington*, 1992.
- [6] Pierre Baldi and Edward Posner. Graph coloring bounds for cellular radio. *Computers Math. Applic.*, 19(10):91–97, 1990.
- [7] Richard Barrett, Michael Berry, Tony F. Chan, James Demmel, June Donato, Jack Dongarra, Victor Eijkhout, Roldan Pozo, Charles Romine, and Henk van der Vorst. *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*. SIAM, 1994.
- [8] M. Benzi. Splittings of symmetric matrices and a question of Ortega. *Linear Algebra and its Applications*, 429:2340–2343, 2008.
- [9] Å. Björck. *Numerical Methods for Least Squares Problems*. SIAM, 1996.
- [10] Susanne C Brenner and Larkin Ridgway Scott. *The mathematical theory of finite element methods*, volume 15. Springer, 2008.
- [11] C. Brezinski. *Accélération de la Convergence en Analyse Numérique*. Number 584 in Lecture notes in Mathematics 584. Springer, 1977.
- [12] M. Bronstein. *Symbolic Integration I : Transcendental Functions*, volume 1 of *Algorithms and Computation in Mathematics*. Springer, 1996.
- [13] J. C. Butcher. On runge-kutta processes of high order, part 2. *J. Austral. Math. Soc.*, IV:179–194, 1964.
- [14] John C Butcher. *Numerical methods for ordinary differential equations*. John Wiley & Sons, 2008.

- [15] B. P. Butler, A. B. Forbes, and P. M. Harris. Algorithms for geometric tolerance assessment. *TR DITC 228/94, National Physical Laboratory, Teddington*, 1994.
- [16] G. Cardano. *Ars Magna or The Rules of Algebra, 1545*. MIT, 1968.
- [17] I. B. Cohen. *Howard Aiken : Portrait of a Computer Planner*. MIT Press, 1999.
- [18] James W. Cooley and John W. Tukey. An algorithm for the machine calculation of complex fourier series. *Math. Comput.*, 19:297–301, 1965.
- [19] I.D. Coope and C.J. Price. A modified BFGS formula maintaining positive definiteness with Armijo-Goldstein steplengths. *Journal of Computational Mathematics*, 13:156–160, 2008.
- [20] C.F. Curtiss and J.O. Hirschfelder. Integration of stiff equations. *Proc. Nat. Acad. Sci. U.S.A.*, 38:235–243, 1952.
- [21] Germund Dahlquist. Convergence and stability in the numerical integration of ordinary differential equations. *Math. Scand.*, 4:33–53, 1956.
- [22] Germund Dahlquist. A special stability problem for linear multistep methods. *BIT*, 3:27–43, 1963.
- [23] G.B. Dantzig. Maximization of a linear function of variables subject to linear inequalities. In T.C. Koopmans, editor, *Activity Analysis of Production and Allocation*, pages 339–347. Wiley, New York, 1951.
- [24] C. de Boor. *A Practical Guide to Splines*. Springer, 1978.
- [25] Carl de Boor. *Splinefunktionen*. Birkhäuser, 1990.
- [26] J. Dongarra, C. Moler, J. Bunch, and G. W. Stewart. *LINPACK Users' Guide*. SIAM, 1979.
- [27] J. Dongarra and F. Sullivan. The top 10 algorithms. *Computing in Science and Engineering*, 2(1):22–23, 2000.
- [28] Michael Drexler and Martin J Gander. Circular billiard. *SIAM review*, 40(2):315–323, 1998.
- [29] L. Euler. *Institutionum Calculi Integralis. Volumen Primum*, volume XI of *Opera OMNIA*. Birkhäuser, 1768.
- [30] Haw-ren Fang and Dianne P. O'Leary. Modified Cholesky algorithms: a catalog with new approaches. *Math. Program., Ser. A*, 115:319–349, 2008.
- [31] K. Fernando and B. Parlett. Accurate singular values and differential qd algorithms. *Numerische Mathematik*, 67:191–229, 1994.
- [32] R. Fletcher. Conjugate gradient methods for indefinite systems. In G. Alistair Watson, editor, *Numerical Analysis– Dundee 1975*, volume 506, pages 73–89. Lecture Notes in Mathematics, Springer-Verlag, Heidelberg, 1976.
- [33] G. Forsythe and P. Henrici. The cyclic jacobi method for computing the principal values of a complex matrix. *Trans. Amer. Math. Soc.*, 94:1–23, 1960.
- [34] J. G. F. Francis. The qr transformation, a unitary analogue to the lr transformation – part 1. *The Computer Journal*, 4:265–271, 1961.
- [35] Roland Freund and Noël Nachtigal. QMR: A quasi-minimal residual method for non-Hermitian linear systems. *Numerische Mathematik*, 60:315–339, 1991.

- [36] A. Gamst and W. Rave. On the frequency assignment in mobile automatic telephone systems. In *Proc. of GLOBECOM 82*, pages 309–315, 1982.
- [37] Martin J. Gander and Felix Kwok. Chladni figures and the Tacoma bridge: motivating PDE eigenvalues problems via vibrating plates. *SIAM Rev.*, 54:573–596, 2012.
- [38] M.J. Gander, K. Santugini, and A. Steiner. La rete stradale piu breve che collega le citta (shortest road network connecting cities). *Bolettino dei docenti di matematica*, 56:9–19, 2008.
- [39] W. Gander. On Halley’s iteration method. *The American Mathematical Monthly*, 92(2), 1985.
- [40] W. Gander. Algorithms for the polar decomposition. *SIAM J. on Sci. and Stat. Comp.*, 11(6), 1990.
- [41] W. Gander. *Computermathematik*. Birkhäuser, 1992.
- [42] W. Gander. Zeros of determinants of λ -matrices. In *Proceedings in Applied Mathematics and Mechanics*, volume 8, pages 10811–10814. Wiley, 2008.
- [43] W. Gander and W. Gautschi. Adaptive quadrature - revisited. *BIT*, 40(1):84–101, 2000.
- [44] W. Gander and D. Gruntz. The billiard problem. *International Journal of Mathematical Education in SCIENCE and Technology*, 23(6):825–830, 1992.
- [45] W. Gander and J. Hřebíček. *Solving Problems in Scientific Computing using Maple AND Matlab*. Springer, 3rd edition, 1997.
- [46] Walter Gander and Dominik Gruntz. Derivation of numerical methods using computer algebra. *SIAM Review*, 41(3), 1999.
- [47] Garbow, Boyle, Dongarra, and Moler. *EISPACK Guide Extension*. Lecture Notes in Computer Science. Springer, 1977.
- [48] Walter Gautschi, Ronald S FRIEDMAN, Jonathan BURNS, Rajan DARJEE, and Andrew MCINTOSH. *Orthogonal Polynomials: Computation and Approximation, Numerical Mathematics and Scientific Computation Series*. Oxford University Press, Oxford, 2004.
- [49] Philip E Gill, Walter Murray, and Margaret H Wright. Practical optimization. 1981.
- [50] L. Giraud, J. Langou, M. Rozložník, and J. van den Eshof. Rounding error analysis of the classical gram-schmidt orthogonalization process. *Numerische Mathematik*, 101:87–100, 2005.
- [51] G. H. Golub and C. F. Van Loan. *Matrix Computations*. Johns Hopkins Studies in the Mathematical Sciences. Johns Hopkins University Press, Baltimore, MD, 1996.
- [52] G. H. Golub and J. H. Welsch. Calculation of gauss quadrature rules. *Math. Comp.*, 23:221–230, 1969.
- [53] Gene Golub and Christian Reinsch. Singular value decomposition and least squares solutions. *Numerische Mathematik*, 14:403–420, 1970.
- [54] Gene H. Golub. *The Use of Chebyshev Matrix Polynomials in the ITERATIVE Solution of Linear Equations Compared to THE Method of Successive*

- Overrelaxation*. PhD thesis, University of Illinois at Urbana-Champaign, 1959.
- [55] Gene H. Golub and William Kahan. Calculating the singular values and pseudo-inverse of a matrix. *SIAM J. Numer. Anal.*, 2:205–224, 1965.
- [56] Gene H. Golub and Victor Pereyra. The differentiation of pseudoinverses and nonlinear least squares problems whose variables separate. *SIAM J. Numer. Anal.*, 10:416–432, 1973.
- [57] N. I. M. Gould and S. Leyffer. An introduction to algorithms for nonlinear optimization. In *Frontiers in Numerical Analysis*, pages 109–197. Springer Verlag, 2003.
- [58] Andreas Griewank and Andrea Walther. *Evaluating Derivatives: Principles and Techniques of ALGORITHMIC Differentiation*. SIAM, 2008.
- [59] Martin Gutknecht. Lanczos-type solvers for nonsymmetric linear systems of equations. *Acta Numerica*, pages 271–397, 1997.
- [60] J. Hadamard. Sur les problèmes aux dérivées partielles et leur signification physique. *Princeton University Bulletin*, 13:49–52, 1902.
- [61] E. Hairer, Ch. Lubich, and G. Wanner. *Geometric Numerical Integration: Structure-Preserving Algorithms for Ordinary Differential Equations*. Springer-Verlag, 2002.
- [62] E. Hairer, S. P. Nørsett, and G. Wanner. *Solving Ordinary Differential Equations I, Nonstiff PROBLEMS*. Springer-Verlag, 2nd revised edition, 1993.
- [63] E. Hairer and G. Wanner. *Solving Ordinary Differential Equations II, the Stiff CASE*. Springer-Verlag, 2nd revised edition, 1994.
- [64] E. Hairer and G. Wanner. *Analysis by Its History*. Springer, New York, 1996.
- [65] R. Hanson and M. Norris. Analysis of measurements based on the singular value decomposition. *SIAM J. on Sci. and Stat. Comp.*, 2(3), 1981.
- [66] Jin-Kao Hao and Raphaël Dorne. Study of genetic search for the frequency assignment problem. In *Artificial Evolution European Conference*, pages 333–344. Springer-Verlag, 1996.
- [67] P. Henrici. On the speed of convergence of cyclic and quasicyclic jacobi methods for computing eigenvalues of hermitian matrices. *J. Soc. Indust. Appl. Math.*, 6:144–162, 1958.
- [68] P. Henrici. *Discrete variable methods in ordinary differential equations*. Wiley, 1962.
- [69] P. Henrici. *Elements of Numerical Analysis*. Wiley, 1964.
- [70] M. Hestenes and E. Stiefel. Methods of conjugate gradients for solving linear systems. *J. Research Nat. Bur. Standards*, 49:409–436, 1952.
- [71] Nicholas J. Higham. *Accuracy and stability of numerical algorithms*. SIAM, 2002.
- [72] A.S. Householder. On the convergence of matrix iterations. Technical Report 1883, Oak Ridge National Laboratory, 1955.
- [73] Thomas JR Hughes. *The finite element method: linear static and dynamic finite element analysis*. DoverPublications. com, 2012.

- [74] C. G. J. Jacobi. über ein leichtes verfahren, die in der theorie der säkularstörungen vorkommenden gleichungen numerisch aufzulösen. *Crelle's Journal*, 30:51–94, 1846.
- [75] F. John. *Advanced Numerical Methods*. Lecture Notes, Department of Mathematics, 1956.
- [76] Johan Joss. *Algorithmishes Differenzieren*. PhD thesis, Eidgenoessische Technische Hochschule, Zürich, Switzerland, 1976.
- [77] William Kahan. *Gauss-Seidel Methods of Solving Large Systems of Linear EQUATIONS*. PhD thesis, University of Toronto, 1958.
- [78] D. K. Kahaner. Comparison of numerical quadratur formulas. *Mathematical Software*, pages 229–269, 1971.
- [79] Narendra Karmarkar. A new polynomial-time algorithm for linear programming. In *Proceedings of the sixteenth annual ACM symposium on Theory of computing*, pages 302–311. ACM, 1984.
- [80] Daniel Kressner. *Numerical methods for general and structured eigenvalue problems*, volume 46. Springer, 2005.
- [81] Jeffrey C. Lagarias, James A. Reeds, Margaret H. Wright, and Paul E. Wright. Convergence properties of the Nelder-Mead simplex method in low dimensions. *SIAM Journal of Optimization*, 9:112–147, 1998.
- [82] Cornelius Lanczos. An iterative method for the solution of the eigenvalue problem of linear differential and integral operators. *J. Res. Nat. Bur. Standards, Sect. B.*, 45:225–280, 1950.
- [83] Cornelius Lanczos. Solution of systems of linear equations by minimized iterations. *J. Res. Nat. Bur. Standards, Sect. B.*, 49:33–53, 1952.
- [84] Ben Leimkuhler and Sebastian Reich. *Simulating Hamiltonian Dynamics*. Cambridge University Press, 2005.
- [85] Steven J. Leon. *Linear Algebra with Applications*. Pearson, 2010.
- [86] Jörg Liesen and Zdenek Strakos. *Krylov subspace methods: principles and analysis*. Oxford University Press, 2012.
- [87] J. Liouville. Remarques nouvelles sur l'équation de riccati. *J. des Math. pures et appl.*, 6:1–13, 1841.
- [88] James N Lyness and Cleve B Moler. Numerical differentiation of analytic functions. *SIAM Journal on Numerical Analysis*, 4(2):202–210, 1967.
- [89] J. Liesen M.Benzi, G.H.Golub. Numerical solution of saddle point problems. *Acta Numerica*, 14:1–137, 2005.
- [90] JB McLeod. A note on the ε -algorithm. *Computing*, 7(1-2):17–24, 1971.
- [91] J. C. P. Miller. *Neville's and Romberg's Processes: A fresh Appraisal with Extensions*, volume 263 of *Series A, Mathematical and Physical Sciences*. Philosophical Transactions of the Royal Society of London, 1969.
- [92] C. Moler. The qr algorithm – striving for infallibility. *MathWorks Newsletter*, 1995.
- [93] Cleve Moler and Charles Van Loan. Nineteen dubious ways to compute the exponential of a matrix. *SIAM Review*, 20(4), 1978.

- [94] A. M. Mood and F. A. Graybill. *Introduction to the Theory of Statistics*. McGraw-Hill Book Company, New York, 2nd edition, 1963.
- [95] I. Newton. *Methodus Fluxionum et Serierum INFINITARUM*, volume 1 of *Opuscula mathematica*. edita Londini, 1736. Traduit en français par M. de Buffon, Paris MDCCXL.
- [96] Alan V. Oppenheim and Alan S. Willsky. *Signals & Systems*. Prentice Hall, 1996.
- [97] Jörg Waldvogel. Fast construction of the fejer and clenshaw-curtis quadrature rules. *BIT*, 46(1):195–202, 2006.
- [98] AM Ostrowski. On the linear iteration procedures for symmetric matrices. *Rend. Mat. Appl*, 14:140–163, 1954.
- [99] A.M. Ostrowski. *Solution of Equations and Systems of Equations*. Academic Press, 1973.
- [100] M. L. Overton. *Numerical Computing with IEEE Floating Point Arithmetic*. SIAM, 2001.
- [101] Chris C. Paige and Michael A. Saunders. Solution of sparse indefinite systems of linear equations. *SIAM J. Numer. Anal.*, 12:617–629, 1975.
- [102] Chris C. Paige and Michael A. Saunders. LSQR: An algorithm for sparse linear equations and sparse least squares. *ACM Trans. Math. Soft.*, 8:43–71, 1982.
- [103] Christopher Conway Paige. *The computation of eigenvalues and eigenvectors of very large sparse matrices*. PhD thesis, University of London, 1971.
- [104] B. N. Parlett. *The Symmetric Eigenvalue Problem*. Classics in Applied Mathematics. SIAM, 2nd edition, 1998.
- [105] Edgar Reich. On the convergence of the classical iterative method of solving linear simultaneous equations. *The Annals of Mathematical Statistics*, 20(3):448–451, 1949.
- [106] Lewis Fry Richardson. On the approximate arithmetical solution by finite differences of physical problems involving differential equations, with an application to the stresses in a masonry dam. *Proceedings of the Royal Society of London. Series A*, 83(563):335–336, 1910.
- [107] M. Rojas, S.A. Santos, and D.C. Sorensen. A new matrix-free algorithm for the large-scale trust-region subproblem. *SIAM J. Optim.*, 11(3):611–646, 2000.
- [108] Walter Rudin. *Real and Complex Analysis*. McGraw-Hill, International Edition, 1987.
- [109] H. Rutishauser. Der quotienten-differenzen-algorithmus. *Z. Angew. Math. Physik*, 5(1):233–251, 1954.
- [110] H. Rutishauser. *Der Quotienten-Differenzen-Algorithmus*. Birkhäuser, 1957.
- [111] H. Rutishauser. *Description of ALGOL 60*. Springer, 1967.
- [112] H. Rutishauser. *Lectures on Numerical Mathematics*. Birkhäuser, 1990.
- [113] H. Rutishauser and H. R. Schwarz. The lr transformation method for symmetric matrices. *Numerische Mathematik*, 5:273–289, 1963.

- [114] Heinz Rutishauser. Über die Instabilität von Methoden zur Integration gewöhnlicher Differentialgleichungen. *ZAMP*, 3:65–74, 1952.
- [115] Heinz Rutishauser. Beiträge zur kenntnis des biorthogonalisierungs- algorithmus von lanczos. *Zeitschrift für angewandte Mathematik und Physik (ZAMP)*, 4(1):35–56, 1953.
- [116] W. Gander S. J. Leon, Å. Björck. Gram-schmidt orthogonalization: 100 years and more. *Numer. Linear Algebra Appl.*, 20:492–532, 2013.
- [117] M. H. Saad, Y. & Schultz. Gmres: A generalized minimal residual algorithm for solving nonsymmetric linear systems. *SIAM J. Sci. Statist. Comput.*, 7:856–869, 1986.
- [118] Yousef Saad. *Iterative Methods for Sparse Linear Systems*. SIAM, 2003.
- [119] J. M. Sanz-Serna. Two topics on nonlinear stability. *Advances in Numerical Analysis (W. Light ed.)*, I:147–174, 1991.
- [120] Ernst Schröder. über iterirte functionen. *Mathematische Annalen*, 3(2):296–322, 1870.
- [121] Ernst Schröder. Über unendlich viele algorithmen zur auflösung der gleichungen. *Mathematische Annalen*, 2(2):317–365, 1870.
- [122] H. R. Schwarz. *Numerik symmetrischer Matrizen*. Teubner, 1972.
- [123] H. Schwetlik and T. Schütze. Least squares approximation by splines with free knots. *BIT*, 35(3):361–384, 1995.
- [124] Daniel Shanks. Non-linear transformation of divergent and slowly convergent sequences. *Journal of Mathematics and Physics*, 34:1–42, 1955.
- [125] Avram Sidi. Efficient implementation of minimal polynomial and reduced rank extrapolation methods. *J. of Comp. and Appl. Math.*, 36:305–337, 1991.
- [126] Avram Sidi and Jacob Bridger. Convergence and stability analyses for some vector extrapolation methods in the presence of defective iteration matrices. *J. of Comp. and Appl. Math.*, 22:35–61, 1988.
- [127] H. Späth. Orthogonal least squares fitting with linear manifolds. *Numer. Math.*, 48:441–445, 1986.
- [128] William Squire and George Trapp. Using complex variables to estimate derivatives of real functions. *Siam Review*, 40(1):110–112, 1998.
- [129] A. Steiner and M. Arrigoni. Die lösung gewisser räuber-beute-systeme. *Studia Biophysica*, 123(2), 1988.
- [130] G. W. Stewart. The economical storage of plane rotations. *Numerische Mathematik*, 25:137–138, 1976.
- [131] E. Stiefel. *Einführung in die numerische Mathematik*. Teubner, 1976.
- [132] J. Stoer and R. Bulirsch. *Introduction to Numerical Analysis*. Springer, 1991.
- [133] Gilbert Strang and George J Fix. *An analysis of the finite element method*, volume 212. Prentice-Hall Englewood Cliffs, 1973.
- [134] A.M. Stuart and A.R. Humphries. *Dynamical Systems and Numerical Analysis*. Mathematics. Cambridge University Press, 1998.

- [135] V. Szebehely. *Theory of Orbits, The restricted problem of three BODIES*. Acad. Press, New York, 1967.
- [136] R.C.E. Tan. Implementation of the topological ε -algorithm. *SIAM J. Sci. Stat. Comput.*, 9(5), 1988.
- [137] F. Tisseur and K. Meerbergen. The quadratic eigenvalue problem. *SIAM. Rev.*, 43:234–286, 2001.
- [138] Joseph F. Traub. *Iterative Methods for the Solution of Equations*. Algorithms and Computation in Mathematics. Prentice Hall, 1964.
- [139] L. N. Trefethen. The definition of numerical analysis. SIAM News, November 1992. Available online at http://people.maths.ox.ac.uk/trefethen/publication/PDF/1992_55.pdf.
- [140] L. N. Trefethen and D. Bau III. *Numerical Linear Algebra*. SIAM, 1997.
- [141] Henk van der Vorst. Bi-CGSTAB: A fast and smoothly converging variant of Bi-CG for the solution of nonsymmetric linear systems. *SIAM J. Sci. Statist. Comput.*, 13:631–644, 1992.
- [142] Richard S. Varga. *Matrix Iterative Analysis*. Prentice Hall, first edition, 1962.
- [143] Vito Volterra. *Leçon sur la théorie mathématique de la lutte pour la vie*. Cahiers Scientifiques, Paris, 1931.
- [144] Urs von Matt. The orthogonal qd-algorithm. *SIAM Journal on Scientific Computing*, 18:1163–1186, 1997.
- [145] J. von Neumann and H.H. Goldstine. Numerical inverting of matrices of high order. *Bull. Amer. Math. Soc.*, 53:479–557, 1947.
- [146] Gene H. Golub Walter Gander and Rolf Strebel. Least-squares fitting of circles and ellipses. *BIT*, 34:558–578, 1994.
- [147] H. Weyl. Das asymptotische Verteilungsgesetz der Eigenwerte linearer partieller Differentialgleichungen (mit einer Anwendung auf die Theorie der Hohlraumstrahlung). *Mathematische Annalen*, 71:441–479, 1912.
- [148] J. Wilkinson and C. Reinsch. *Linear Algebra*. Springer, 1971.
- [149] J. H. Wilkinson. Error analysis of direct methods of matrix inversion. *Journal of the ACM (JACM)*, Volume 8 Issue 3:281–330, 1961.
- [150] J. H. Wilkinson. *The Algebraic Eigenvalue Problem*. Monographs on Numerical Analysis. Oxford Science Publications, 1965.
- [151] P. Wynn. On a device for computing the $e_m(s_n)$ -transformation. *MTAC*, 10:91–96, 1956.
- [152] P. Wynn. General purpose vector epsilon algorithm algol procedures. *Numerische Mathematik*, 6:22–36, 1964.
- [153] David M. Young. *Iterative Methods for Solving Partial Difference EQUATIONS of Elliptic Type*. PhD thesis, Harvard University, May 1950.
- [154] K. Zuse. *The computer, my life*. Springer, 1993.

Index

- A-norm, 746
- $A(\alpha)$ -stability, 655
- A-Stability, 650
- Adams-Bashforth method, 633
- Adaptive Integration, 617
- Adaptive Quadrature, 563
- Admissible Basis, 870
- Affine Krylov subspace, 746
- Aitken acceleration, 193
- Aitken–Neville Scheme, 537
- Algorithm
 - ε -algorithm, 196
 - Arnoldi, 433, 438, 760
 - BiCG-stab, 801
 - Biconjugate Gradient (BiCG), 793
 - BiORES, 790
 - Björck Algorithm for Covariance Matrix, 322
 - classical Gram-Schmidt, 302
 - classical Runge-Kutta method, 614
 - conjugate gradients CGHS, 743
 - conjugate residuals, 705
 - FOM for Solving Linear Systems, 767
 - Golden Section Minimization, 820
 - Golub–Welsch quadrature, 557
 - Golub-Kahan-Lanczos, 457
 - Gram-Schmidt, 301, 548
 - Heun’s Order 3 ODE solver, 612
 - implicit QR Algorithm, 443
 - Jacobi, 405
 - Laguerre’s Method, 240
 - Lanczos, 438
 - Lanczos for Solving Linear Systems, 769
 - Lanczos tridiagonalization, 436
 - LR-Cholesky, 470
 - machine-independent, 21, 48, 50, 186, 422, 564
 - MINRES, 780
 - modified Gram-Schmidt, 303
 - Nelder–Mead, 859
 - Newton-Maehly, 232
 - Orthogonal LR-Cholesky, 468
 - Orthomin, 796
 - Preconditioned Conjugate Gradient, 803
 - QD Algorithm, 464, 467
 - QMR, 801
 - QR Algorithm, 429, 436
 - quotient-difference, 464
 - Romberg, 537
 - Simplex, 862
 - SOR, 695
 - SSOR, 724
 - stable, 34
 - SVD of Golub-Reinsch, 458
 - Thomas, 99
 - Trust Region, 857
 - unstable, 34
- Algorithmic Differentiation, 499
- Approximation
 - by polynomial, 129
 - data fitting, 131
- Arenstorf orbit, 618
- Arithmetic
 - standard model, 19

- Armijo Backtracking Line Search, 844
 Arnoldi process, 758
 ASCII code, 227
 Automatic Differentiation, 499
 Autonomous ODE, 603
- Back substitution, 68, 76
 Backward differentiation formulas (BDF), 632
 Backward stability, 36
 Banach space, 242
 Barrier Function, 873
 Base, 13
 Bernoulli number, 533
 BFGS Method, 856
 Biconjugate Gradient Method, 793, 801
 Bidiagonalization, 454
 Big-O notation, 27
 Biharmonic Operator, 498
 Binary search, 147, 252
 Binary system, 13
 Biorthogonal matrices, 781
 Bisection method, 185
 Block-Jacobi, 693
 Boole's Rule, 522
 error, 526
 Boundary conditions
 clamped, 152
 natural, 148, 150
 not a knot, 152
 periodic, 149, 154, 158
 Boundary value problem, 587
 Brachistochrone Problem, 488
 Butcher tableau, 606
- Cancellation, 45, 46
 avoiding, 43, 47, 49, 493
 Cardano formulas, 217
 Chan-Transformation, 454
 Chaos, 215
 Characteristic equation, 640
 Characteristic polynomial, 5, 389
 Chebyshev
 nodes, 121
 polynomials, 121, 713
 Semi-Iterative Method, 719
 three term recurrence, 714
- Chladni figures, 387
 Cholesky decomposition, 91, 268
 Choosing a time step, 620
 Circular Billiard, 505
 Compression of a signal, 178
 Computation of π
 stable, 21
 unstable, 11
 Computation of limits, 142
 Computation range, 18
 Computing
 2-norm, 272
 exponential function, 48
 logarithm function, 57
 covariance matrix, 320
 determinant, 510
 exponential function, 43
 exponential function stable, 49
 Frobenius norm, 272
 sine function, 58
 singular value decomposition, 453
 square root, 49
 Standard deviation, 45
 with power series, 593
- Condition, 24
 ill-conditioned problem, 29
 linear equations, 84
 number, 29, 285
 of Eigenvalues, 398
 well-conditioned problem, 29
- Conjugate directions, 740
 Conjugate Gradient, 743, 771, 843
 as convergence accelerator, 750
 Craig's Method (CGNE), 801
 Method, 740
 on Normal Equations (CGNR), 801
 reduction to tridiagonal matrix, 751
 three term recurrence, 750
 Conjugate residuals, 705

- Consistency, 636
- Continuation method, 251
- Convergence
 - cubic, 205
 - linear, 191
 - multiple zeros, 205
 - QR Algorithm, 445
 - quadratic, 246
 - rate, 191
 - secant method, 209
 - super-quadratic, 212
 - superlinear, 209
- Convergence factor
 - asymptotic, 686
 - mean, 686
- Convergence rate
 - asymptotic, 686
 - mean, 686
- Convolution, 168, 170
- Coordinate metrology, 344
- Covariance Matrix
 - Björck Algorithm, 322
- Covariance matrix, 320
- Cramer's Rule, 66

- Dahlquist barrier
 - first, 646
 - second, 655
- Data fitting problems, 131
- Decomposition
 - LU Factorization, 73
 - Cholesky, 91
- Definite integral, 517
- Delay Differential Equations, 664
- Denormalized numbers, 17
- Derivative
 - finite difference, 491
- Descent method, 740
- Determinant, 63, 76
 - Laplace Expansion, 64
 - Leibniz formula, 64
- Diagonalizing
 - circulant matrices, 178
- Difference
 - absolute, 51
 - relative, 51
- Differential algebraic equation (DAE), 656
- Differential equations
 - homogeneous linear system, 398
- Differentiation
 - Algorithmic, 499
 - numerical, 21, 494
- Digit, 13
- Discretization, 675
- Divide and conquer principle, 563
- Divided differences, 123, 134
- Double precision, 15
- Dynamical systems, 212

- Eccentric anomaly, 182
- Eigenvalue
 - algebraic multiplicity, 397
 - condition, 398
 - deflation, 449
 - geometric multiplicity, 397
 - orthogonal iteration, 425
 - Power Method, 422
 - Schur decomposition, 427
 - shift-and-Invert, 424
- Eigenvalue problem, 5, 389
- Elimination
 - with Givens rotations, 95
- Ellipse, 56
 - eccentricity, 184
- Elliptic integral, 56
- Embedded Runge-Kutta methods, 620
- Energy norm, 746
- Energy Preserving Methods, 661
- Equation
 - goniometric, 515
 - nonlinear, 6, 181, 240
 - quadratic, 55
- ERMETH, 14
- Error
 - a posteriori error estimate, 243
 - a priori error estimate, 244
 - absolute, 51
 - discretization, 494

- global truncation, 615
- iteration, 190
- local truncation for one step method, 606
- measurement, 132
- relative, 51
- trigonometric interpolation, 164
- Error vector, 679
- Euler–Maclaurin Summation Formula, 531, 534
- Explicit Linear Multistep Methods, 638
- Exponent, 13
- Exponential function
 - computing, 43
- Extrapolation, 115, 142
 - Aitken–Neville, 143
 - Richardson, 143, 538
 - Romberg, 143
- Extrapolation methods for linear systems, 726
- Factorization
 - LU* Factorization, 73
- Farkas Lemma, 842
- Fast Givens, 298
- Feigenbaum constant, 214
- Finite difference, 23, 28
 - one-sided, 491
 - symmetric, 493
- Finite precision arithmetic, 13
- First Dahlquist barrier, 646
- First order system, 603
- Fixed point
 - Banach theorem, 242
 - contraction, 243
 - form, 187
 - iteration, 187, 242
- Fixed point iteration, 58
- Floating point number, 13
- Formal Power Series, 532
- Forward Euler method, 599
- Forward stability, 33, 36
- Forward substitution, 76
- Fourier
 - aliasing, 166
 - coefficients, 159
 - conditioning, 176
 - convolution, 168
 - Cooley–Tukey Algorithm, 163
 - decomposition, 158
 - discrete transform, 161
 - fast transform (FFT), 162
 - FFT and convolution, 171
 - harmonics, 159
 - impulse response, 168
 - inverse discrete transform, 161
 - series, 158
 - unit impulse, 168
- Fréchet derivative, 282
- Fractal, 250
- Fractals, 251
- Frobenius Norm, 807
- Frobenius norm, 342, 346
- Full Orthogonalization Method (FOM), 766
- Function
 - gradient, Hessian, 834
 - LambertW, 188, 819
 - minimum, maximum, 832
 - multiple zeros, 205
 - root, 181
 - zero, 181
- Fundamental Subspaces, 275
- Fundamental subspaces, 275
- Galerkin condition, 766
- Gauss Quadrature Rule, 541
- Gauss transformations, 800
- Gauss–Kronrod Rule, 569
- Gauss–Legendre Quadrature Rule, 543
- Gauss–Lobatto Rule, 569
- Gauss–Newton method, 6
- Gauss–Markoff Theorem, 267
- Gauss–Newton method, 360, 367
- Gauss–Seidel Method, 694
- Gaussian Elimination, 66
 - column pivoting, 330
 - rank-one changes, 82
- Gaussian elimination, 3

- General linear multistep method, 635
 General solution of ODE, 587
 general system of linear equations, 107
 Generalized Minimum Residual method (GMRES), 773
 Geometric integration, 656
 Ghost eigenvalues, 765
 Givens reflection, 293
 Givens rotation, 292
 Givens rotations, 103, 408
 Givens transformations
 generalized, 478
 Global error, 712
 Global truncation error, 615
 Golden Section, 820
 Golden section equation, 209
 Golub–Welsch Algorithm, 557
 Gradient, 241, 354
 Gram–Schmidt procedure, 548
 Gram–Schmidt with Reorthogonalization, 306
 Growth factor, 78, 82

 Hadamard Product, 826
 Heat equation, 675
 Heron’s formula, 50
 Hessenberg matrix, 297, 759
 Hessian, 354
 Hexadecimal, 17
 Hilbert matrix, 111
 Horner’s scheme
 complete, 226
 simple, 223
 Householder matrix, 289

 IEEE floating point standard, 14
 Ignore a singularity, 564
 Implicit Linear Multistep Methods, 637
 Implicit Midpoint Method, 629
 Implicit trapezoidal method, 633
 Infinity, Inf, 15, 17
 Initial condition, 587
 Initial or boundary conditions, 587
 Initial value problem, 587

 Integral
 definite, 517
 Integration
 Romberg, 143, 537
 trapezoidal rule, 165
 Interior Point Method, 872, 873
 Interpolating
 function, 115
 Interpolation, 113
 Aitken–Neville, 139, 210
 Aitken–Neville scheme, 139
 Barycentric Formula, 121, 122
 by polynomials, 116
 Chebyshev nodes, 121
 data fitting, 131
 divided differences, 123
 error, 115, 119
 Hermite, 146
 inverse, 210
 Lagrange, 117
 Newton, 123
 Runge’s example, 121
 spline cardinal form, 146
 splines, 145
 trigonometric polynomial, 161
 interpolation principle, 113
 Inverse iteration, 107
 Inverse Power Method, 424
 Iteration
 correction form, 678
 Halley, 201
 inner and outer, 199
 inverse interpolation, 209
 Müller’s method, 209
 multi-step methods, 207
 Newton, 199
 one step method, 199
 Regula Falsi, 209
 Schröder’s method, 207
 secant method, 207
 single stage, 678
 successive iterates, 245
 Iteration matrix, 678
 Iterative method
 non-stationary, 704

- Iterative Methods
 - stationary, 678
- Jacobi Method, 691
- Jacobi rotations, 409
- Jacobian, 355
- Jacobian matrix, 837
- Jordan block, 394
- Joukowski transformation, 776
- Kahan's Summation Algorithm, 39
- Kantorovitch inequality, 707
- Karush-Kuhn-Tucker Theorem, 840
- Kepler
 - equation, 182, 184, 199
 - second law, 182
- Krylov Space, 728
- Krylov subspace methods, 739
- Lagrange
 - polynomial, 117
- Lagrange multipliers, 838
- Lagrangian, 838
- Lanczos Algorithm, 550
- Lanczos Bidiagonalization Process, 457
- Lanczos for non-symmetric matrices, 780
- Lanczos vector, 762
- Lanczos-Algorithm, 128, 550
- Laplace operator, 675
- Laplacian, 496
- Law of cosines, 55
- Least squares
 - algebraic distance, 337
 - condition, 285
 - constrained, 335, 336
 - constrained linear, 367
 - constrained nonlinear, 367
 - ellipse fitting, 337
 - fit hyperplane, 343
 - fit parallel lines, 336, 337
 - fit with piecewise functions, 364
 - linear constraints, 323
 - linear problem, 266
 - metrology, 344
 - minimum-norm solution, 278
 - nonlinear problem, 354
 - normal equations, 129
 - problem, 129, 261
 - solution by QR, 287
 - special quadratic constraint, 334
- Least-squares problem, 6
- Line fitting, 335
- Line-Jacobi, 693
- Linear Equation
 - extrapolation algorithms, 728
- Linear multistep methods, 631
- Linear system
 - backward error analysis, 84
 - banded, 97
 - full matrices, 66
 - Gaussian Elimination, 66
 - general, 107
 - iterative methods, 4, 673
 - rank p change, 156
 - symmetric matrices, 88
 - time-invariant (LTI), 170
 - tridiagonal, 99, 103
 - under-determined, 279
- Lipschitz, 243
- Little-O notation, 27
- Local Truncation Error
 - Multistep Methods, 635
- Local truncation error for one step
 - method, 606
- Lotka-Volterra Equations, 657
- LU decomposition, 4
- M-matrix, 688
- Machine constants, 53
- Machine number, 11
 - range, 13
- Machine precision, 13, 17, 53
- Mantissa, 13
- MARK 1, 14
- Matrix
 - permutation, 75
 - augmented, 70, 458
 - augmented system, 155
 - band, 4

- banded, 97
- block-diagonal, 367
- capacitance, 156
- Cholesky decomposition, factorization, 91
- circulant, 170
- coefficients, 62
- column, 63
- companion, 221
- condition number, 85, 86
- conjugate transpose, 400
- defective, 395
- determinant, 396
- diagonalizable, 392, 397
- diagonally dominant, 692
- eigen-decomposition, 393
- eigenvalue, 389
- eigenvector, 389
- elementary Householder, 455
- exponential, 397
- functions, 398
- fundamental subspaces, 275
- Golub-Kahan-Lanczos bidiagonalization, 457
- Hessenberg, 430
- Hessian, 242, 834
- Hilbert matrix, 86
- implicit bidiagonalization, 456
- irreducible, 468, 687
- Jacobian, 241, 245, 367, 837
- Jacobian numerically, 247
- Jordan decomposition, 681
- LDU decomposition of symmetric matrix, 769
- LU decomposition, 75
- non-negative, 687
- non-positive, 687
- normal, 400
- null space, 275, 837
- operator, 291
- orthogonal, 269
- positive definite, 89
- projection on Krylov subspace, 759
- pseudo-inverse, 737
- range, 837
- range or column space, 275
- rank, numerical rank, 279
- rank-one change, 70
- rank-p change, 156
- reduction to bidiagonal form, 454
- reduction to Hessenberg form, 430
- reduction to tridiagonal form, 434
- row space, 275
- rows, 63
- similar, 396
- sparse, 4
- symmetric tridiagonal, 232
- Toeplitz, 265, 533
- trace, 396
- transformation, 133
- triangular decomposition, 75, 76
- tridiagonal, 150, 151
- unreduced, 449
- upper triangular, 68
- Vandermonde, 116, 368
- Vandermonde matrices, 86
- Matrix norm
 - induced, 680
- Matrix splitting, 677
- Method
 - Adams–Bashforth two-step, 633
 - Adams–Bashforth, 633
 - Adams–Moulton, 634
 - Backward Euler, 631
 - Dormand–Prince, 624
 - explicit s -stage Runge–Kutta, 605
 - Explicit Linear Multistep, 638
 - Explicit Midpoint Rule, 632
 - Forward Euler, 631
 - Gauss–Legendre Runge–Kutta, 630
 - general one step method for ODE, 605
 - Hammer and Hollingsworth Runge–Kutta, 630
 - Heun, 611

- Implicit Linear Multistep, 637
- Implicit Midpoint Method, 629
- implicit Runge-Kutta, 625
- Implicit Trapezoidal Method, 628
- improved or modified Euler, 611
- Kuntzmann and Butcher Runge-Kutta, 631
- linear multistep, 635
- Runge, 611
- Runge-Kutta-Fehlberg, 624
- Method of Householder, 289
- Method of Richardson, 702, 704
- Mid-Point Rule, 579
- Minimal norm solution, 278
- Minimal polynomial, 712
- Minimal Polynomial Extrapolation (MPE), 729
- Minimization
 - with Armijo backtracking line search, 846
- Minimum
 - global, 370
 - local, 370
- Modified Minimal Polynomial Extrapolation (MMPE), 734
- Modified Newton Methods, 854
- Moving average, 377
- Nelder-Mead algorithm, 859
- Newton
 - for systems, 245
- Newton correction, 245
- Newton Search Direction, 850
- Newton's Iteration, 49
- Newton's method, 6
- Newton-Cotes Rule, 521
 - closed type, 522
 - error, 525
 - open type, 523
 - second kind, 523
- Newton-Maehly Method, 551
- Newton-Maehly Method, 234
- Non-Symmetric Lanczos Process, 783
- Nonlinear Eigenvalue Problem, 509
- Nonlinear equations, 6
- Nonlinear System, 240
- Norm, 24
 - 1-norm, 25, 26
 - 2-norm, 24, 26, 272
 - polynomial, 127
 - equivalent, 26
 - Euclidean, 24
 - Frobenius, 26, 272, 826
 - induced matrix norm, 26
 - infinity, 25, 26, 825
 - matrix, 25
 - maximum, 25
 - maximum column sum norm, 26
 - maximum row sum norm, 26
 - one norm, 825
 - spectral, 24, 26, 825
 - submultiplicative property, 25
 - vector, 24
- Normal Equations, 268
- Normal equations, 129, 345
- Normed vector space, 242
- Not a number, NaN, 15, 17
- Null Space, 837
- Null space method, 333
- Number
 - conversions, 227
 - denormalized, 15, 17, 18, 53
 - double precision, 15, 16
 - floating point, 13
 - hexadecimal, 15
 - normalized, 13, 53
 - single precision, 14
 - subnormal, 15, 17
- Numerical differentiation, 21, 32
- Operations Research, 828
- Operator principle, 677
- Optimality Conditions, 838
- Optimization
 - active set for the local optimum, 840
 - constraint, 862
 - constraints, 831
 - direct method, 859

- line search methods, 842
- problem, 831
- problem classification, 831
- Optimization algorithms, 6
- Order
 - ODE solver, 608
- Order Conditions
 - for linear multistep methods, 636
- Order conditions
 - for one step methods, 611
- Ordinary differential equation (ODE), 587
- Orthogonal Polynomial, 546
- Orthogonal projector, 276
- Orthogonal QD Step, 472
- Overflow, 18, 55
 - avoiding, 41
 - test for, 42
- Parasitic solution, 642
- Partial reorthogonalization, 308
- Penalty Function, 873
- Penrose Equations, 274
- Perron–Frobenius Theorem, 823
- Petrov–Galerkin Condition, 787
- Pivot
 - banded system, 100
 - complete pivoting, 81, 82, 107
 - diagonal pivoting, 90, 93
 - element, 71
 - no pivoting, 92, 99
 - partial pivoting, 72
 - strategy, 72
- Pivoting strategy, 36
- Point–Jacobi Method, 691
- Polar decomposition, 347
- Polynomial
 - approximation, 129
 - basis, 132
 - characteristic, 5, 216, 389, 396
 - Chebyshev, 713, 717
 - deflation, 216
 - Hermite, 146
 - Lagrange, 117, 132
 - Laguerre’s Method, 239
 - Legendre, 546, 549
 - monomials, 132
 - Newton, 133
 - Newton polynomials, 123
 - Newton’s Method, 230
 - Nickel’s Method, 237
 - orthogonal, 127, 133, 232, 546, 547, 550, 715
 - suppression of zeros, 234
 - Taylor expansion, 226
 - trigonometric, 160
 - Wilkinson’s polynomial, 217
 - zeros, 215
- Preconditioned system, 678
- Preconditioner, 678
- Preconditioning, 802
- Principle axis transformation, 338
- Problem
 - ill-conditioned, 32, 372
 - ill-posed, 32
 - well-posed, 32
- Procrustes problem, 346–348
- Projector on subspace, 341
- Projectors on subspaces, 276
- Property A, 696
- Pseudoinverse, 274
- QD Algorithm
 - differential, 464
 - progressive, 464
 - Rhombus Rules, 466
- QD Line, 465
- QD Rhombus-Rules, 466
- QD Scheme, 466
- QD Step
 - differential, 472
 - orthogonal, 472
 - progressive, 467
- QR decomposition, 288
- QR factorization
 - implicit by Givens
 - transformations, 296
 - implicit by Householder transformations, 290
 - updating, 311

- QR Iteration, 437
 - chasing the bulge, 442
- QR with implicit shift, 442
- Quadratic Programming Problem, 879
- Quadrature, 517
- Quadrature of the circle, 10, 517
- Quadrature Rule
 - composite, 527
 - order, 526
- Quasi minimum residual, 801
- Quasi-Newton Methods, 855
- Radix, 13
- Range, 837
- Rayleigh quotient, 423, 749
- Recurrence
 - error, 679
 - residuals, 679
- Recurrence for residuals, 704
- Recurrence relation
 - three-term, 550
- Reduced Rank Extrapolation (RRE), 733
- Region of absolute stability, 650
- Regular splitting, 687
- Residual, 51, 678
- Residual polynomial, 712, 747, 774
- Residual vector, 262, 354
- Restricted Three Body Problem, 617
- Richardson Extrapolation, 538
- Richardson extrapolation, 143
- Riemann sum, 3, 519
- Riemann Zeta function, 535
- Riemann–Lebesgue lemma, 159
- Romberg Scheme, 538
- Rounding error
 - absolute, 19
 - associative law, 38
 - avoiding cancellation, 21
 - cancellation, 20, 24, 30, 55
 - relative, 19
- Rounding Errors, 19
- Runge's method, 605
- Runge-Kutta
 - derivation with MAPLE, 611
 - embedded methods, 620
 - implicit methods, 625
- Saddle point problem, 878
- Sampling theorem, 167
- Satellite, 182
- Savitzky-Golay Filter, 377
- SAXPY, 68
- Schur decomposition, 427
- Second Dahlquist barrier, 655
- Separation of variables, 585
- Sequential Quadratic Programming, 877
- Shanks transform, 194
 - generalized, 195
- Sherman-Morrison-Woodbury Formula, 110, 156
- Shift-and-Invert, 424
- Signal compressing, 159
- Significant, 13
- Simplex Algorithm, 862
- simplex table, 865
- Simpson's Rule, 522
 - composite, 529
 - error, 526
 - error composite rule, 530
- Singular linear systems, 683
- Singular perturbation problems, 655
- Singular value
 - decomposition (SVD), 270
- Singular values, 270, 453
- Singular vectors, 270, 453
- Spectral radius, 680
- Spline
 - cubic, 147
 - curves, 157
 - defective spline, 149
- Squaring of a circle, 10
- SSOR, symmetric successive over relaxation, 724
- Stability, 33
 - backward, 36

- forward, 33
- Standard linear model, 267
- Steepest Descent, 705, 843, 848
- Stencil, 495, 496
- Stiff problem, 646
- Stirling Formula, 48
- Stopping criterion, 48, 51
 - machine-independent, 49, 50, 57, 186, 448, 462, 564
 - monotonicity, 50
 - successive approximations, 51
 - successive iterates, 58
- Submultiplicative property, 807
- Subnormal numbers, 17
- Successive over-relaxation (SOR), 695
- Summation Algorithm by W. Kahan, 39
- Summation function, 531
- Suspension bridge, 1
- Symmetric Lanczos iteration, 762
- Symplectic Methods, 658
- System
 - nonlinear, 491
- System of ordinary differential equations, 598

- Tacoma bridge, 387
- Tacoma Narrows bridge, 4
- Taylor
 - multivariate expansion, 240, 241
- Taylor expansion, 28
- TEA, 735
- Termination criterion, 21, 49
 - monotonicity, 40
- Test equation, 642
- Theorem
 - Gershgorin, 403
 - ImplicitQ-Theorem, 438
- Thomas Algorithm, 99
- Three term recurrence relation, 714
- Three-term recurrence relation, 549
- Toeplitz matrix, 265
- Topological ε -Algorithm, 735
 - recursive, 737
- Total least squares, 349
 - constrained, 351
- Transformation
 - elementary similarity, 408
 - Similarity, 396
 - to Hessenberg form, 430
 - to tridiagonal form, 434
- Transformation to Hessenberg-form, 760
- Trapezoidal Rule, 521, 522
 - asymptotic expansion, 535
 - composite, 527
 - error, 526
 - error composite rule, 527
- Trapezoidal rule
 - asymptotic expansion, 142
- Triangle inequality, 24
- Truncated Newton Methods, 856
- Trust region, 364
- Trust Region Methods, 856
- Two point boundary value problem, 587
- Two-body problem, 182

- Underflow range, 18
- Unstable method, 639
- Updating the QR Decomposition, 311

- Vandermonde
 - LU decomposition, 136
 - QR decomposition, 138
- Vandermonde matrix, 116
- Vector epsilon algorithm (VEA), 737
- Vieta's formula, 55

- Weddle's Rule, 522
- Weighting of measurement errors, 379

- Wilkinson Matrix, 452
- Wilkinson's Principle, 20
- Wilkinson's principle, 36
- Wilkinson's shift, 447

- Zero-Stability, 642
- Zuse Z3, 14

Editorial Policy

1. Textbooks on topics in the field of computational science and engineering will be considered. They should be written for courses in CSE education. Both graduate and undergraduate textbooks will be published in TCSE. Multidisciplinary topics and multidisciplinary teams of authors are especially welcome.
2. Format: Only works in English will be considered. For evaluation purposes, manuscripts may be submitted in print or electronic form, in the latter case, preferably as pdf- or zipped ps-files. Authors are requested to use the LaTeX style files available from Springer at: <http://www.springer.com/authors/book+authors/helpdesk?SGWID=0-1723113-12-971304-0> (Click on → Templates → LaTeX → monographs)
Electronic material can be included if appropriate. Please contact the publisher.
3. Those considering a book which might be suitable for the series are strongly advised to contact the publisher or the series editors at an early stage.

General Remarks

Careful preparation of manuscripts will help keep production time short and ensure a satisfactory appearance of the finished book.

The following terms and conditions hold:

Regarding free copies and royalties, the standard terms for Springer mathematics textbooks hold. Please write to martin.peters@springer.com for details.

Authors are entitled to purchase further copies of their book and other Springer books for their personal use, at a discount of 33.3% directly from Springer-Verlag.

Series Editors

Timothy J. Barth
NASA Ames Research Center
NAS Division
Moffett Field, CA 94035, USA
barth@nas.nasa.gov

Michael Griebel
Institut für Numerische Simulation
der Universität Bonn
Wegelerstr. 6
53115 Bonn, Germany
griebel@ins.uni-bonn.de

David E. Keyes
Mathematical and Computer Sciences
and Engineering
King Abdullah University of Science
and Technology
P.O. Box 55455
Jeddah 21534, Saudi Arabia
david.keyes@kaust.edu.sa

and

Department of Applied Physics
and Applied Mathematics
Columbia University
500 W. 120th Street
New York, NY 10027, USA
kd2112@columbia.edu

Risto M. Nieminen
Department of Applied Physics
Aalto University School of Science
and Technology
00076 Aalto, Finland
risto.nieminen@aalto.fi

Dirk Roose
Department of Computer Science
Katholieke Universiteit Leuven
Celestijnenlaan 200A
3001 Leuven-Heverlee, Belgium
dirk.roose@cs.kuleuven.be

Tamar Schlick
Department of Chemistry
and Courant Institute
of Mathematical Sciences
New York University
251 Mercer Street
New York, NY 10012, USA
schlick@nyu.edu

Editor for Computational Science
and Engineering at Springer:
Martin Peters
Springer-Verlag
Mathematics Editorial IV
Tiergartenstrasse 17
69121 Heidelberg, Germany
martin.peters@springer.com

Texts in Computational Science and Engineering

1. H. P. Langtangen, *Computational Partial Differential Equations*. Numerical Methods and Diffpack Programming, 2nd Edition.
2. A. Quarteroni, F. Saleri, P. Gervasio, *Scientific Computing with MATLAB and Octave*, 3rd Edition.
3. H. P. Langtangen, *Python Scripting for Computational Science*, 3rd Edition.
4. H. Gardner, G. Manduchi, *Design Patterns for e-Science*.
5. M. Griebel, S. Knapek, G. Zumbusch, *Numerical Simulation in Molecular Dynamics*.
6. H. P. Langtangen, *A Primer on Scientific Programming with Python*, 3rd Edition.
7. A. Tveito, H. P. Langtangen, B. F. Nielsen, X. Cai, *Elements of Scientific Computing*.
8. B. Gustafsson, *Fundamentals of Scientific Computing*.
9. M. Bader, *Space-Filling Curves*.
10. M.G. Larson, F. Bengzon, *The Finite Element Method: Theory, Implementation, and Applications*.
11. W. Gander, M.J. Gander, F. Kwok, *Scientific Computing*. An Introduction using Maple and MATLAB.

For further information on these books please have a look at our mathematics catalogue at the following URL: www.springer.com/series/5151

Monographs in Computational Science and Engineering

1. J. Sundnes, G.T. Lines, X. Cai, B.F. Nielsen, K.-A. Mardal, A. Tveito, *Computing the Electrical Activity in the Heart*.

For further information on this book, please have a look at our mathematics catalogue at the following URL: www.springer.com/series/7417

Lecture Notes in Computational Science and Engineering

1. D. Funaro, *Spectral Elements for Transport-Dominated Equations*.
2. H.P. Langtangen, *Computational Partial Differential Equations*. Numerical Methods and Diffpack Programming.
3. W. Hackbusch, G. Wittum (eds.), *Multigrid Methods V*.
4. P. Deuffhard, J. Hermans, B. Leimkuhler, A.E. Mark, S. Reich, R.D. Skeel (eds.), *Computational Molecular Dynamics: Challenges, Methods, Ideas*.

5. D. Kröner, M. Ohlberger, C. Rohde (eds.), *An Introduction to Recent Developments in Theory and Numerics for Conservation Laws*.
6. S. Turek, *Efficient Solvers for Incompressible Flow Problems*. An Algorithmic and Computational Approach.
7. R. von Schwerin, *Multi Body System SIMulation*. Numerical Methods, Algorithms, and Software.
8. H.-J. Bungartz, F. Durst, C. Zenger (eds.), *High Performance Scientific and Engineering Computing*.
9. T.J. Barth, H. Deconinck (eds.), *High-Order Methods for Computational Physics*.
10. H.P. Langtangen, A.M. Bruaset, E. Quak (eds.), *Advances in Software Tools for Scientific Computing*.
11. B. Cockburn, G.E. Karniadakis, C.-W. Shu (eds.), *Discontinuous Galerkin Methods*. Theory, Computation and Applications.
12. U. van Rienen, *Numerical Methods in Computational Electrodynamics*. Linear Systems in Practical Applications.
13. B. Engquist, L. Johnsson, M. Hammill, F. Short (eds.), *Simulation and Visualization on the Grid*.
14. E. Dick, K. Rienslagh, J. Vierendeels (eds.), *Multigrid Methods VI*.
15. A. Frommer, T. Lippert, B. Medeke, K. Schilling (eds.), *Numerical Challenges in Lattice Quantum Chromodynamics*.
16. J. Lang, *Adaptive Multilevel Solution of Nonlinear Parabolic PDE Systems*. Theory, Algorithm, and Applications.
17. B.I. Wohlmuth, *Discretization Methods and Iterative Solvers Based on Domain Decomposition*.
18. U. van Rienen, M. Günther, D. Hecht (eds.), *Scientific Computing in Electrical Engineering*.
19. I. Babuška, P.G. Ciarlet, T. Miyoshi (eds.), *Mathematical Modeling and Numerical Simulation in Continuum Mechanics*.
20. T.J. Barth, T. Chan, R. Haimes (eds.), *Multiscale and Multiresolution Methods*. Theory and Applications.
21. M. Breuer, F. Durst, C. Zenger (eds.), *High Performance Scientific and Engineering Computing*.
22. K. Urban, *Wavelets in Numerical Simulation*. Problem Adapted Construction and Applications.
23. L.F. Pavarino, A. Toselli (eds.), *Recent Developments in Domain Decomposition Methods*.

24. T. Schlick, H.H. Gan (eds.), *Computational Methods for Macromolecules: Challenges and Applications*.
25. T.J. Barth, H. Deconinck (eds.), *Error Estimation and Adaptive Discretization Methods in Computational Fluid Dynamics*.
26. M. Griebel, M.A. Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations*.
27. S. Müller, *Adaptive Multiscale Schemes for Conservation Laws*.
28. C. Carstensen, S. Funken, W. Hackbusch, R.H.W. Hoppe, P. Monk (eds.), *Computational Electromagnetics*.
29. M.A. Schweitzer, *A Parallel Multilevel Partition of Unity Method for Elliptic Partial Differential Equations*.
30. T. Biegler, O. Ghattas, M. Heinkenschloss, B. van Bloemen Waanders (eds.), *Large-Scale PDE-Constrained Optimization*.
31. M. Ainsworth, P. Davies, D. Duncan, P. Martin, B. Rynne (eds.), *Topics in Computational Wave Propagation*. Direct and Inverse Problems.
32. H. Emmerich, B. Nestler, M. Schreckenberg (eds.), *Interface and Transport Dynamics*. Computational Modelling.
33. H.P. Langtangen, A. Tveito (eds.), *Advanced Topics in Computational Partial Differential Equations*. Numerical Methods and Diffpack Programming.
34. V. John, *Large Eddy Simulation of Turbulent Incompressible Flows*. Analytical and Numerical Results for a Class of LES Models.
35. E. Bänsch (ed.), *Challenges in Scientific Computing - CISC 2002*.
36. B.N. Khoromskij, G. Wittum, *Numerical Solution of Elliptic Differential Equations by Reduction to the Interface*.
37. A. Iske, *Multiresolution Methods in Scattered Data Modelling*.
38. S.-I. Niculescu, K. Gu (eds.), *Advances in Time-Delay Systems*.
39. S. Attinger, P. Koumoutsakos (eds.), *Multiscale Modelling and Simulation*.
40. R. Kornhuber, R. Hoppe, J. Périaux, O. Pironneau, O. Wildlund, J. Xu (eds.), *Domain Decomposition Methods in Science and Engineering*.
41. T. Plewa, T. Linde, V.G. Weirs (eds.), *Adaptive Mesh Refinement – Theory and Applications*.
42. A. Schmidt, K.G. Siebert, *Design of Adaptive Finite Element Software*. The Finite Element Toolbox ALBERTA.
43. M. Griebel, M.A. Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations II*.

44. B. Engquist, P. Lötstedt, O. Runborg (eds.), *Multiscale Methods in Science and Engineering*.
45. P. Benner, V. Mehrmann, D.C. Sorensen (eds.), *Dimension Reduction of Large-Scale Systems*.
46. D. Kressner, *Numerical Methods for General and Structured Eigenvalue Problems*.
47. A. Boriçi, A. Frommer, B. Joó, A. Kennedy, B. Pendleton (eds.), *QCD and Numerical Analysis III*.
48. F. Graziani (ed.), *Computational Methods in Transport*.
49. B. Leimkuhler, C. Chipot, R. Elber, A. Laaksonen, A. Mark, T. Schlick, C. Schütte, R. Skeel (eds.), *New Algorithms for Macromolecular Simulation*.
50. M. Bücker, G. Corliss, P. Hovland, U. Naumann, B. Norris (eds.), *Automatic Differentiation: Applications, Theory, and Implementations*.
51. A.M. Bruaset, A. Tveito (eds.), *Numerical Solution of Partial Differential Equations on Parallel Computers*.
52. K.H. Hoffmann, A. Meyer (eds.), *Parallel Algorithms and Cluster Computing*.
53. H.-J. Bungartz, M. Schäfer (eds.), *Fluid-Structure Interaction*.
54. J. Behrens, *Adaptive Atmospheric Modeling*.
55. O. Widlund, D. Keyes (eds.), *Domain Decomposition Methods in Science and Engineering XVI*.
56. S. Kassinos, C. Langer, G. Iaccarino, P. Moin (eds.), *Complex Effects in Large Eddy Simulations*.
57. M. Griebel, M.A Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations III*.
58. A.N. Gorban, B. Kégl, D.C. Wunsch, A. Zinovyev (eds.), *Principal Manifolds for Data Visualization and Dimension Reduction*.
59. H. Ammari (ed.), *Modeling and Computations in Electromagnetics: A Volume Dedicated to Jean-Claude Nédélec*.
60. U. Langer, M. Discacciati, D. Keyes, O. Widlund, W. Zulehner (eds.), *Domain Decomposition Methods in Science and Engineering XVII*.
61. T. Mathew, *Domain Decomposition Methods for the Numerical Solution of Partial Differential Equations*.
62. F. Graziani (ed.), *Computational Methods in Transport: Verification and Validation*.
63. M. Bebendorf, *Hierarchical Matrices. A Means to Efficiently Solve Elliptic Boundary Value Problems*.

64. C.H. Bischof, H.M. Bücker, P. Hovland, U. Naumann, J. Utke (eds.), *Advances in Automatic Differentiation*.
65. M. Griebel, M.A. Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations IV*.
66. B. Engquist, P. Lötstedt, O. Runborg (eds.), *Multiscale Modeling and Simulation in Science*.
67. I.H. Tuncer, Ü. Gülcat, D.R. Emerson, K. Matsuno (eds.), *Parallel Computational Fluid Dynamics 2007*.
68. S. Yip, T. Diaz de la Rubia (eds.), *Scientific Modeling and Simulations*.
69. A. Hegarty, N. Kopteva, E. O’Riordan, M. Stynes (eds.), *BAIL 2008 – Boundary and Interior Layers*.
70. M. Bercovier, M.J. Gander, R. Kornhuber, O. Widlund (eds.), *Domain Decomposition Methods in Science and Engineering XVIII*.
71. B. Koren, C. Vuik (eds.), *Advanced Computational Methods in Science and Engineering*.
72. M. Peters (ed.), *Computational Fluid Dynamics for Sport Simulation*.
73. H.-J. Bungartz, M. Mehl, M. Schäfer (eds.), *Fluid Structure Interaction II – Modelling, Simulation, Optimization*.
74. D. Tromeur-Dervout, G. Brenner, D.R. Emerson, J. Erhel (eds.), *Parallel Computational Fluid Dynamics 2008*.
75. A.N. Gorban, D. Roose (eds.), *Coping with Complexity: Model Reduction and Data Analysis*.
76. J.S. Hesthaven, E.M. Rønquist (eds.), *Spectral and High Order Methods for Partial Differential Equations*.
77. M. Holtz, *Sparse Grid Quadrature in High Dimensions with Applications in Finance and Insurance*.
78. Y. Huang, R. Kornhuber, O. Widlund, J. Xu (eds.), *Domain Decomposition Methods in Science and Engineering XIX*.
79. M. Griebel, M.A. Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations V*.
80. P.H. Lauritzen, C. Jablonowski, M.A. Taylor, R.D. Nair (eds.), *Numerical Techniques for Global Atmospheric Models*.
81. C. Clavero, J.L. Gracia, F. Lisbona (eds.), *BAIL 2010 – Boundary and Interior Layers, Computational and Asymptotic Methods*.
82. B. Engquist, O. Runborg, Y.R. Tsai (eds.), *Numerical Analysis and Multiscale Computations*.

83. I.G. Graham, T.Y. Hou, O. Lakkis, R. Scheichl (eds.), *Numerical Analysis of Multiscale Problems*.
84. A. Logg, K.-A. Mardal, G. Wells (eds.), *Automated Solution of Differential Equations by the Finite Element Method*.
85. J. Blowey, M. Jensen (eds.), *Frontiers in Numerical Analysis - Durham 2010*.
86. O. Kolditz, U.-J. Gorke, H. Shao, W. Wang (eds.), *Thermo-Hydro-Mechanical-Chemical Processes in Fractured Porous Media - Benchmarks and Examples*.
87. S. Forth, P. Hovland, E. Phipps, J. Utke, A. Walther (eds.), *Recent Advances in Algorithmic Differentiation*.
88. J. Garcke, M. Griebel (eds.), *Sparse Grids and Applications*.
89. M. Griebel, M. A. Schweitzer (eds.), *Meshfree Methods for Partial Differential Equations VI*.
90. C. Pechstein, *Finite and Boundary Element Tearing and Interconnecting Solvers for Multiscale Problems*.
91. R. Bank, M. Holst, O. Widlund, J. Xu (eds.), *Domain Decomposition Methods in Science and Engineering XX*.
92. H. Bijl, D. Lucor, S. Mishra, C. Schwab (eds.), *Uncertainty Quantification in Computational Fluid Dynamics*.
93. M. Bader, H.-J. Bungartz, T. Weinzierl (eds.), *Advanced Computing*.
94. M. Ehrhardt, T. Koprucki (eds.), *Advanced Mathematical Models and Numerical Techniques for Multi-Band Effective Mass Approximations*.
95. M. Azaïez, H. El Fekih, J.S. Hesthaven (eds.), *Spectral and High Order Methods for Partial Differential Equations ICOSAHOM 2012*.
96. M.P. Desjarlais, F. Graziani, R. Redmer, S.B. Trickey (eds.), *Frontiers and Challenges in Warm Dense Matter*.
97. J. Garcke, D. Pflüger (eds.), *Sparse Grids and Applications - Munich 2012*.
98. J. Erhel, M. Gander, L. Halpern, G. Pichot, T. Sassi, O. Widlund (eds.), *Domain Decomposition Methods in Science and Engineering XXI*.
99. R. Abgrall, H. Beaugendre, P.M. Congedo, C. Dobrzynski, M. Ricchiuto, V. Perrier (eds.), *High Order Nonlinear Numerical Methods for Evolutionary PDEs - HONOM 2013*.

For further information on these books please have a look at our mathematics catalogue at the following URL: www.springer.com/series/3527